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Therapeutic potential and ownership of commercially available consoles in children with Cerebral Palsy

Short title: Families with Cerebral Palsy and commercial consoles

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Research Ethics

The study was approved by Lancaster Ethics Committee (NRES: NW1499). No ethical problems were identified. Survey returns were anonymous, with each survey given a unique identifier.

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Declaration of conflicting interest

The Authors declare that there are no conflicts of interest

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Abstract

Introduction: We conducted a survey amongst families of children with cerebral palsy (CP) to ascertain the ownership and therapeutic use and potential of commercial games consoles to improve motor function.

Method: 300 families in southeast England were identified through clinical records, and were requested to complete an anonymised questionnaire.

Results: A total of 61 families (20% response) returned a completed questionnaire with 41 (68%) males and 19 (32%) females with Cerebral Palsy, with a mean age of 11Y5M (SD 3Y 7M). The large majority of families, 59 (97%), owned a commercial console and the child used this for 50-300 minutes a week. Returns by severity of motor impairment were: Gross Motor Function Classification System (GMFCS) I (21%), II (31%), III (13%), IV (15%), V (18%). Consoles were used regularly for play across all GMFCS categories.

Conclusion: The potential of games consoles, as home-based virtual reality therapy (VRT), in improving the motor function of children with cerebral palsy should be appropriately tested in randomised controlled trial. Wide ownership, and the relative ease with which children engage in the use of commercial-based VRT systems suggests potential as a means of augmenting therapy protocols, taking advantage of interest and participation patterns of families.

Keywords

Cerebral Palsy, commercial consoles, survey

What the study has added

This study shows that there is wide ownership/use of commercial games consoles amongst children with CP; and this offers great potential to test therapeutic efficacy of home-based virtual reality therapy to improve motor function in children.

Key messages

Children with Cerebral Palsy frequently access and use commercial consoles during play at home.

Consoles are used by children across severity of gross motor function levels.

Some families had utilized the consoles for therapeutic purposes, with anecdotal improvements in motor function.

Opportunity exists for using commercial consoles within home based therapy protocols and for recreational participation across all GMFCS levels.

Introduction

Cerebral palsy (CP) has been described as “a group of disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain.”

(Rosenbaum et al 2007 p9). The heterogeneity of CP is further reflected in the frequency of co-occurring problems including: deficits in sensation, perception, communication, cognition and epilepsy (Rosenbaum et al 2007, Reid and Campbell 2006). As a result outcomes for children with CP vary with impairments impacting functional ability, participation in daily activities, and general quality of life (Imms 2008). Opportunities to participate in leisure activities are also limited (Skikako-Thomas et al 2008), with mastery motivation, as well as involvement with rehabilitation services, facilitating participation (Majnemar et al 2008).

CP affects up to 2 children per 1000 live births in the UK (National-Institute-for-Health-and-Clinical-Excellence 2012), or 254,000 live births globally (World Health Organisation 2006). The delivery of therapy programmes that have sufficient regularity and intensity to engage children is a challenge, and the ‘ideal dose’ is not known.

Literature review

Interventions and Adherence to Therapy

A national survey of therapeutic interventions for children who have CP in the United Kingdom National Health Service found therapy time decreases as children age, from 12 hours per year for 0-6 year olds, to 7 hours for 12-18 year olds (Coombe et al 2012). Fedrizzi et al (2003) cite how therapy time reduces for children with unilateral CP once they start attending school. Conversely, therapy time levels increase in line with severity rather than age. The Gross Motor Function Classification System (GMFCS) defines the severity of CP from I-V with I being ambulatory and V being most severely physically affected and need full assistance for mobility (Josenby et al 2009). Children at GMFCS level I at 12-18 years are reported as receiving as little as 2.3 hours of therapy time per year. Yet, intensive occupational or physical therapies for children aged 3-9 years shows improvements in motor skills and self-care (less need for assistance), with the biggest gains seen in children at GMFCS levels I-II (Coombe et al 2012), with gains in upper limb function also reported in older children (aged 7-16 years) who have significant impairments in manual ability (Green et al 2013).

The need for increased therapy across GMFCS levels and age groups could be aided by home-based exercise programmes (Katz-Leurer et al 2009). As home exercise programmes are poorly tolerated by some children and their families (Bryanton et al 2006), Virtual Reality Therapy (VRT) offers a potential mechanism to bypass problems of adherence to home exercise protocols. The past two decades have shown an increase in use of computers within school and computer gaming, with children as young as six

years playing electronic games for up to an hour daily (Ramos et al 2005). The potential to exploit this phenomenon is of interest with respect to clinical applications of low-cost, off-the-shelf gaming systems (Deutsch et al 2008).

Virtual Reality Therapy

VRT in children with CP focuses on a wide variety of outcomes that cluster around 1) upper limb function (e.g. manual ability, grasping, spontaneous bimanual use) 2) balance (e.g. single leg stance, jumping) 3) gross motor function (e.g. sitting, standing, walking, running) 4) energy expenditure 5) bone density and 6) functional tasks such as street crossing or shopping (Wilson et al 2016). The therapeutic potential of VRT has been explored using consoles like the Nintendo Wii™, Wii Fit™, and more recently the Xbox Kinect™, including for post stroke rehabilitation in adults, and has shown varied but generally promising results (Bryanton et al 2006, Deutsch et al 2008, Jannink et al 2008, Laufer and Weiss 2011, Shih et al 2012, Mitchell et al 2012,). The first documented use of a commercial system, the Nintendo Wii™ was a single case study of a child with spastic unilateral CP (Deutsch et al 2008). Since then smaller studies using the Nintendo Wii™ sports (excluding the balance board) (Gordon et al 2012), EyeToy playstation (Janninck et al 2008) and a randomized controlled trial using the Wii Fit™ games (Ramstrand and Lynegard 2012) with children with CP and varying intensities of therapy dose, have shown mixed results. More recent work with children with spastic

hemiplegia, using the Nintendo Wii Fit™ in a small single-subject experimental design showed promise to transfer gains to improved running speed and agility (Jelsma et al 2012).

Conversely, bespoke systems, such as GestureTEK IREX are seen as expensive and inaccessible to most of the population (Green and Wilson 2014). Whilst they promise much in the potential to be more personalized, they have also had varied and clinically insignificant results (e.g. James et al 2015). Commercial console use with children with CP has thus been almost double that of bespoke systems (927 vs 545 studies retrieved from Google Scholar to account for human computer interaction studies), but with few undertaken within the home (140 recorded studies).

Our own research with children with Developmental Coordination Disorder (DCD) using the Nintendo Wii Fit™ at school showed improvements in balance and motor co-ordination using a standardised assessment that tailed off after a one-month therapeutic period (Hammond et al 2014). However, increases in motivational factors such as positive self-perceptions of movement skills were maintained. Following this earlier study, the capacity of VRT was considered for children with CP. Parents endorsed this focus during clinic-based preliminary work as a means to meet, in part, the challenge of delivering high-intensity therapy within the NHS via commercially available tools such as the Nintendo Wii™. As one parent explained during study development:

“As a parent I know that my child, along with others, is keen to engage with modern technology in most aspects of life, from assisting with school work, communicating with others and as a form of entertainment. If therapy was delivered using a "computer games" format, I feel that my child would be much keener to engage in undertaking necessary tasks and exercises”.

VRT shows promise as an acceptable therapeutic adjunct for children with CP but currently variations in dose, frequency, tools, outcomes measures, and results limit interpretation (Snider et al 2010). Current studies with VRT may also suffer from bias due to unknown motivational aspects or hidden effects of digital systems, and /or selection bias (e.g. if boys like a gaming system more than girls), in addition to availability of technology in the home. Before home-based VRT can even be successfully trialled (e.g. see Levac and Miller 2012), an understanding is needed of the availability of computerized gaming systems within the home and the usage and role these play for the child and family.

Aims of the study

This survey was the first stage in a study funded by the National Institute for Health Research focusing on the feasibility of use of the Nintendo Wii Fit™ in the home as an addition to regular therapy care for children with CP (PB-PG-0613-31046). The survey investigated the ownership and use of commercial games consoles, including active

games consoles, in the home amongst families of children with CP. Additionally we asked whether these systems had been used as therapeutic interventions and parents' perceptions of any improvements in motor function.

Methods

Recruitment and Consent

Children with CP were identified from clinical lists of Community NHS Trust Child Development Teams in a Southern county in England. Inclusion criteria were: diagnosed with CP; any level of movement ability (GFMCS levels I-V) child of school age 5-16 years old; and, under the care of local NHS staff. The sample was taken from across a county in the south east of England where there is mixed income (Gill 2015).

Contact was made via postal survey or parents were approached by filling out the survey before or after attending regular clinical appointments. Participants were given time to read the patient information sheet, and ask questions about the study before taking part. Patient information sheets were produced for adults, children over 8, and children under-8 years of age.

Measures

Parents were asked to complete a survey consisting of five questions (see appendix for full survey):

- Enquiry as to the type of any consoles in the home
- How many hours each week were spent playing on the console(s)
- Whether the child had ever used a gaming system as a treatment or therapy
- What that system was – if identifiable – and if the system in the parent’s opinion helped improve motor function.
- About the child’s motivation for the system, whether they liked doing games as therapy, and how easy it was to encourage their child to participate in the programme or games.

Distribution

Three hundred questionnaires were sent out to child development teams in the south east of England based on estimates of approximately 300-350 children with CP across all GMFCS levels living in the area. Surveys were divided up into blocks of 50 for 5 local child development centres (CDCs) and a specialist unit for children with complex motor disorders. Each CDC was given additional copies of the recruitment letter, patient information sheet, and a poster to advertise the study and stamped addressed envelopes for return of paper questionnaires. It was decided not to distribute surveys on-line, as it would not be possible to control for data contamination if filled out by individuals outside of the focus geographical area. Data collection took place over a four-month period.

Analysis of Findings

Quantitative data were analysed using basic descriptive statistics (frequency, mean). A medical statistician produced the quantitative results from a de-identified dataset using Stata (Stata 2015). Two researchers read qualitative comments. Main issues were extracted using thematic analysis, with a semantic level of interpretation where only explicit comments made by respondents were identified and arranged into themes (Braun and Clarke 2006).

Results

Characteristics of Respondents

Respondent characteristics are shown in table 1. Sixty-one questionnaires (20%) were returned. Two CDCs confirmed complete distribution (100 surveys), two more CDCs distributed half of the surveys (50 surveys in total) and two CDCs did not document distribution. The majority of surveys were returned by post (40/61) or following face-to-face contact at clinic after care teams asked if they were willing to participate (19/61). Surveys were reported for 68% male and 31% female children with CP. Returns increased across age groups from 23% for 5-8 year olds, 36% for 9-12 years and 41% for 13-16 year olds (median age 11Y 5M; SD 3Y 7M). Returns by GMFCS levels were highest for Level II (19/61, 31%) with more families with male children represented at

GMFCS levels III-V. Frequency of respondents by gender and GMFCS level is shown in figure 1.

Insert table 1 here

Insert figure 1 here

Console Ownership

Ninety-six percent (59/61) of all households owned a commercial console. Console ownership by respondents fell into four main console types; Nintendo™, Microsoft™, Playstation™ and Apple™ systems. Two households had no commercial system. The Nintendo Wii™ (N=37), Wii Fit™ (N=16), and Nintendo DS™ (N=26), along with the Xbox™ (N=26) and Xbox Kinect™ (N=15) accounted for the majority of ownership, with 120 (68%) out of 176 consoles in 61 households. The Apple iPad™ whilst not classed as a console was included by most parents as a commercial gaming system.

Console Use

The average number of minutes played by console per week varied considerably and did not reflect volume of ownership (figure 2). Overall, most children used their

device for interaction as a non-physically interactive games console for leisure. The iPad was the most used piece of equipment on a weekly basis with an average of over 300 minutes per household per child, per week, followed by the Xbox (150 minutes per week). It is worth noting that iPad data was gathered under the 'other' column so figures reported here may well be higher, as some recipients may not have included the iPad in their amount of weekly use as this information was not specifically sought.

Insert figure 2 here

Previous therapy with commercial consoles

Children who have used a commercial console system as a treatment or therapy made up 28/61 responses (46%), with the Wii™, the Wii™ Fit as the most common device that had been used (18/28). One parent reported the use of a bespoke piece of software for improving motor function and was part of a research project at a university. Two other parents reported using the PC for keyboard practice to focus on fine-motor skills, and another parent was utilizing the iPad for their child with a similar outcome, but none of these three families were following a specific programme of therapy.

Insert figure 3 here

Impact of commercial consoles

Parents who used commercial systems for therapy (18/61) reported that they had not caused any detrimental effects. Thirteen parents (13/18, 72%) reported slight to significant improvements in motor function when using commercially available consoles, but this represented a small proportion (13/61, 21%) of the overall survey. The devices perceived to cause no change were the Nintendo Wii Fit™ (4/18) and the Microsoft Kinect (1/18). Two parents reported the Apple iPad having a significant positive impact on motor function.

Insert figure 4 here

Children's attitudes to commercial consoles

The majority of children's attitudes to games as therapy on commercial consoles (as reported by parents) were positive; 15/26 respondents, (73%) indicated that their child 'liked' or liked 'very much' the idea of doing games as therapy. Six children (23%) of children, they 'did not mind' doing therapy virtually, with 4% (1 child) indicating they did not like doing games as therapy. Furthermore, parents reported having little problem encouraging, motivating or prompting their child to participate in the games when used as therapy. Parents stated children were able to do the games in a

self-initiated way (52%, 14/27) or with minimal prompting (30%, 8/27) with the remaining 18% (5/27) needing ‘much prompting’.

Thematic Analysis

Thirty-two parents made qualitative comments with regard to virtual reality therapy. These were read and arranged according to themes when they were repeated across the majority of individuals that responded (Braun and Clarke 2006). These broadly fell into three main themes: type of therapy and games-play, accessibility, and levels of engagement.

Type of Therapy and Games-play

The most reported parental comment was that parents questioned which systems could be useful. Parents in the survey had either bought a console in the past, or their child had used systems in schools, but all were pro-active, interested, and were keen to know which systems might be beneficial for their child. Parents listed games or activities which had been attempted in the past, or the way the games worked (e.g. creating cause and effect). Parents wanted to know what was being targeted by the use of commercial systems, whether a specific skill, a certain type of function such as balance, or a particular muscle group.

Accessibility

Parents expressed concern about whether children would be able to use consoles unaided, and if so, what adaptations would be made to the console system. They were concerned about the amount of help children would need, especially if the virtual reality therapy system was to be used in the home. Parents were also concerned about whether their child would be able to understand instructions given by a console.

Levels of Engagement

Parents were concerned about the amount of motivation children would need to sustain a programme on a commercial console e.g. one parent reported that their child “initially needed much prompting”. Many wondered if children would get bored, or frustrated with a system. For example one parent commented that therapy using consoles:

“Encourage[d] balance and coordination at the age of 6-8 years. Helped with a lot of things as part of a package of care. It was a fun way of doing physio, until the novelty wore off.”

Parents were therefore concerned about the sustainability of commercial systems to engage children for any sustained length of time.

Discussion

Our survey replicated the finding that very few families and children have had access to bespoke systems for VR therapy (Green and Wilson 2014) but most homes are in possession of low-cost, off-the-shelf gaming system (Deutsch et al 2008). The availability and frequency of use of these technologies at home provide opportunities to exploit typical daily play and leisure activities for either therapeutic purposes or even as an outcome measure. What is not known from the survey results is the extent to which the commercial consoles are used in family games or social activities with peers.

In considering the potential use of VR systems as home based therapeutic adjuncts, a number of families reported using commercial systems for therapy goals. Those that had used a system with therapy objectives did not report any detrimental effects, with most parents reporting slight to significant improvements in motor function. Furthermore, parents reported that their child ‘liked’ or ‘liked very much’ the idea of doing games as therapy with many self-initiating participation. Higher levels of engagement alongside mastery motivation have been shown to enhance therapy outcomes for children with unilateral CP (Miller et al 2014). This is not necessarily reflected by increased adherence to therapy protocols, despite positive outcomes, using a purposively designed computerized interactive gaming system (MiTii™) in the home (James et al 2016). Sakzweski et al (in press) recently found children with acquired brain injury to have more limited engagement with the MiTii™ with either boredom or frustration (or other factors) reducing participation and adherence over time. The

limited acceptability by children with movement problems for use of a semi-bespoke system, designed to address motor and perceptual impairments, has implications for applications of VR and computer-based therapies within the home context. On the one hand games and activities within bespoke and semi-bespoke systems are more readily scaled to meet individual needs and capacity (avoiding frustration). On the other hand, these systems may not be seen as fun and playful but rather, perceived as ‘therapy exercises’ and hence lack intrinsic motivation to capture the children’s interest over time.

Parents’ comments reflected these concerns regarding the capacity of a commercial system to sustain sufficient engagement over time. Additionally, parents worried about the level of support that children might need to be able to access and use a commercial system for therapy and wanted professional advice about what games to encourage and what therapeutic benefit there was in consoles. Similarly, other studies have reported therapists as having positive attitudes towards the adoption of VRT, but were concerned about available professional time, and knowledge about the technology or intervention, so as to advise appropriately (Glegg et al 2013).

Of note in our findings was the bias of respondents from parents of older children. This may reflect a decrease in opportunities for age-appropriate recreational activities and or the reduction in therapy intervention levels delivered for older children, with parents keen to identify new formats of therapy for older children. Children at

GMFCS level I between 12-18 years have been reported as receiving as little as 2.3 hours of intervention per year (Coombe et al 2012). Yet these children were seen to be using commercial systems for between 50 to 300 minutes per week; suggesting that home-based VRT using commercial systems may be an acceptable and viable way to enhance therapy input and subsequent outcomes for older children (e.g. see Katz-Leurer et al 2009, Novak et al 2009). Poor take-up of home-based exercise protocols for children (Bryanton et al 2006, Sakzewski et al in press) may be compensated for if commercial systems show an advantage to adherence to therapy, particularly as systems are already present in many homes. What remains to be seen is the extent to which commercial systems, which are perceived as typical recreational computer/VR systems can perform a dual role as therapeutic adjunct alongside facilitating participation in play and leisure activities.

Strengths and Limitations

These results represent a small sample of 61 children (20% response) and represents a limited geographical area, and without socio-economic background. Questions on which there were few responses e.g. with regards to impact of devices on motor function, were too limited to draw conclusions. The data presented here must be taken as illustrative of potential, rather than representative of the issues facing the adoption of VRT across health services. Nevertheless, this survey starts to clarify commercial console ownership

in the home with respect to usage, types of systems and potential for targeting VRT by gender and by severity of CP.

Therapeutic Implications

Commercial-interactive (gaming) systems are an inherent part of children's modern lives, as much for children with disabilities as for typically developing children. With the availability of therapy restricted but the accessibility of technologies becoming more affordable, home-based use of VRT is compelling. This will not be possible until more evidence is available as to the clear therapeutic impact of systems. This survey shows a potential therapeutic target for VRT in children with CP to not only support motor skill acquisition but enhance participation in age-appropriate recreational activities.

Conclusion

Parents and families appear interested in the use of commercial consoles for children with CP across all levels of severity, where potential therapeutic benefits could extend from balance in ambulatory CP (e.g. GMFCS I and II) to upper limb function and control in more severe CP, reflected in widespread iPad use. Parents are actively engaged in processes to find new modalities of therapy for their children especially as children appear motivated to use commercial systems. The relative ease of encouraging

children to engage in use of commercial-based VRT systems suggests potential as a means of augmenting therapy protocols within meaningful daily recreational activities.

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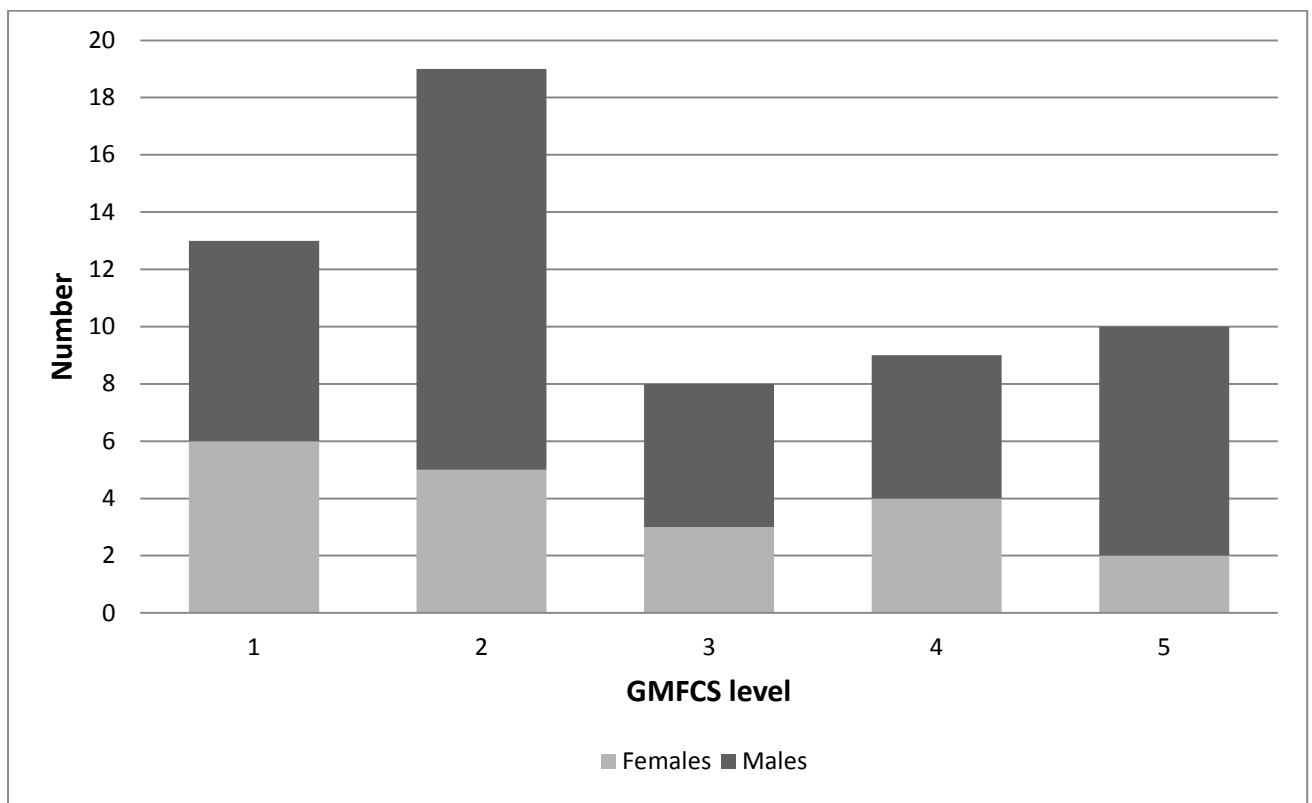
Table 1. Respondent characteristics arranged by Gross Motor Function Classification System Level

GMFCS* Level	Level I	Level II	Level III	Level IV	Level V
N (Mean Age Years, Range)	13 (10.7, 5-16.1)	19 (11.3, 5.2-11.3)	8 (13.39, 11.5 – 15.3)	9 (10.4, 5 - 16.2)	11 (11.1, 5-16.2)
Gender M / F	M 7, F 6	M 14, F 5	M 5, F 3	M 6, F 3	M 9, F 2
Number of Home consoles (Mean, Range)	38 (3.5, 0-6)	45 (4, 0-7)	21 (1.9, 0-5)	26 (2.4, 1-6)	21 (1.9, 1-4)
Hours consoles used per week (Median)	111.95 (3)	100.25 (1)	78.6 (8.5)	93 (5)	52 (0.5)
Hours consoles used for therapy all time (Mean)	3 (0)	9 (0)	7 (1)	3 (0)	3 (0)

GMFCS = Gross motor function classification system, V is severest; N = number of respondents; M = Male; F=Female

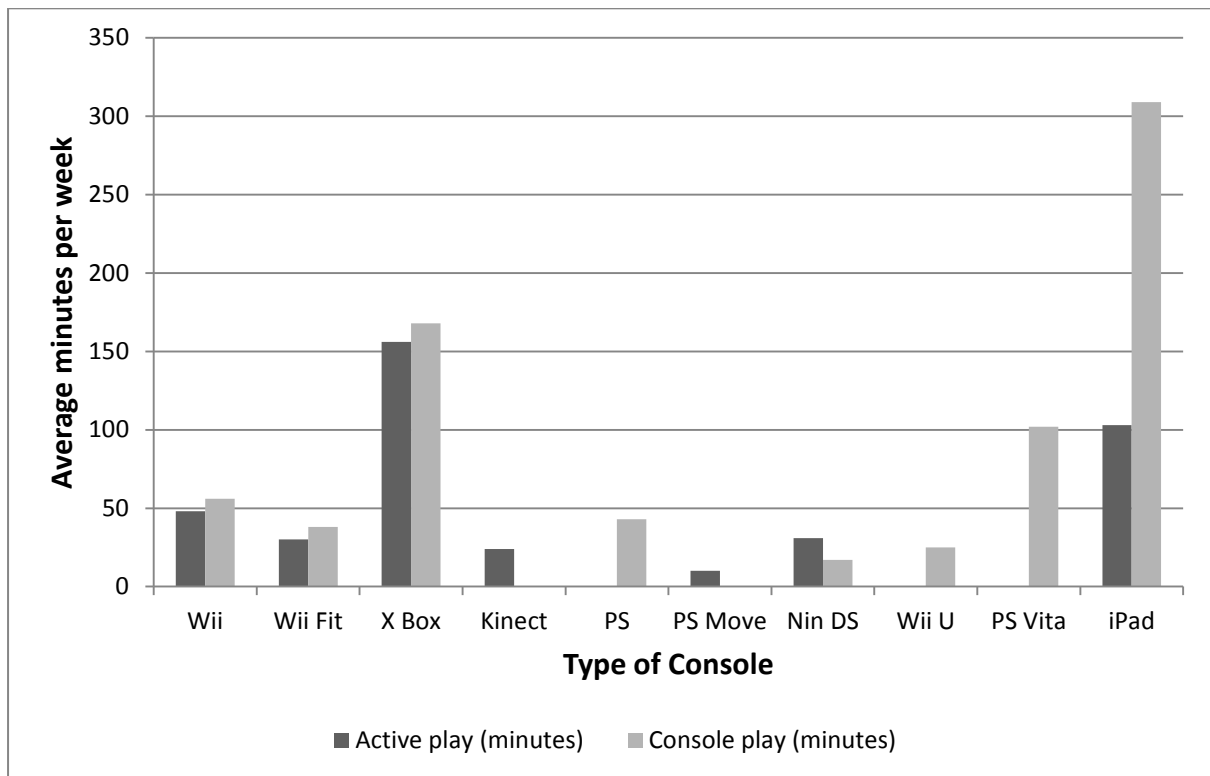
*1 individual did not indicate GMFCS level

Figure 1. Number of respondents by Gender and GMFCS level.



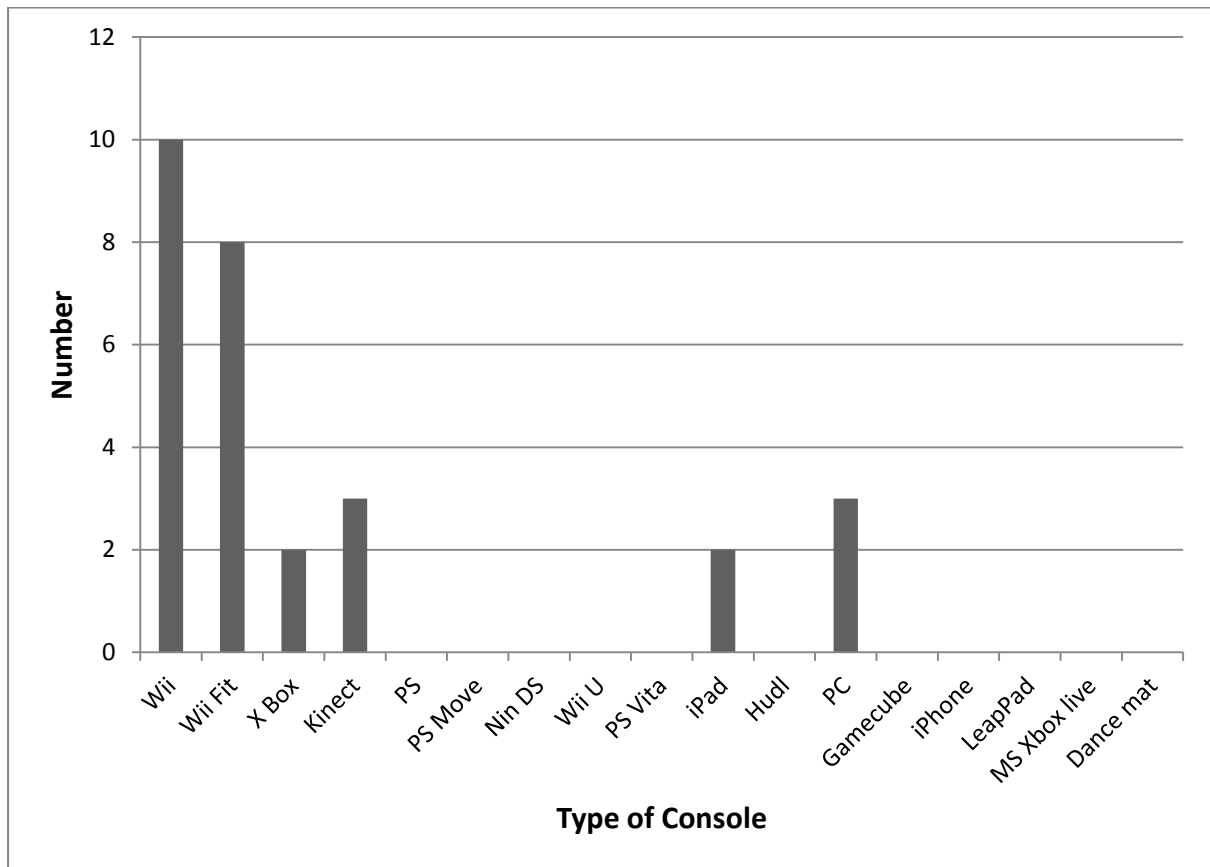
GMFCS = Gross Motor Function Classification System

Figure 2. Number of hours children play on commercial consoles on average per week.



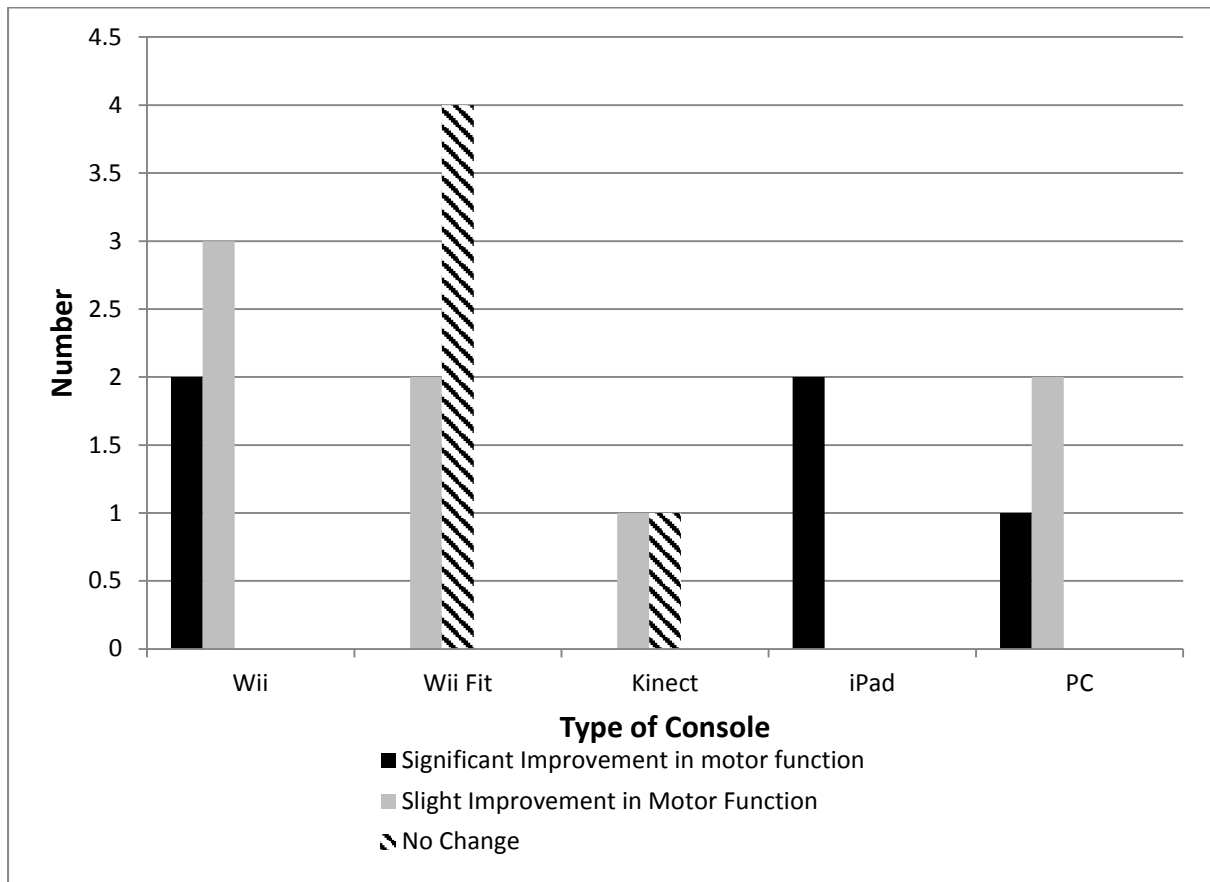
PS=Playstation; Nin DS=Nintendo DS

Figure 3. Number of children who have used a gaming system as treatment or therapy to improve motor function. N=28 respondents.



PS= playstation; PC = personal computer

Figure 4. Number of children whose parents reported device impact on motor function.



PC = personal computer